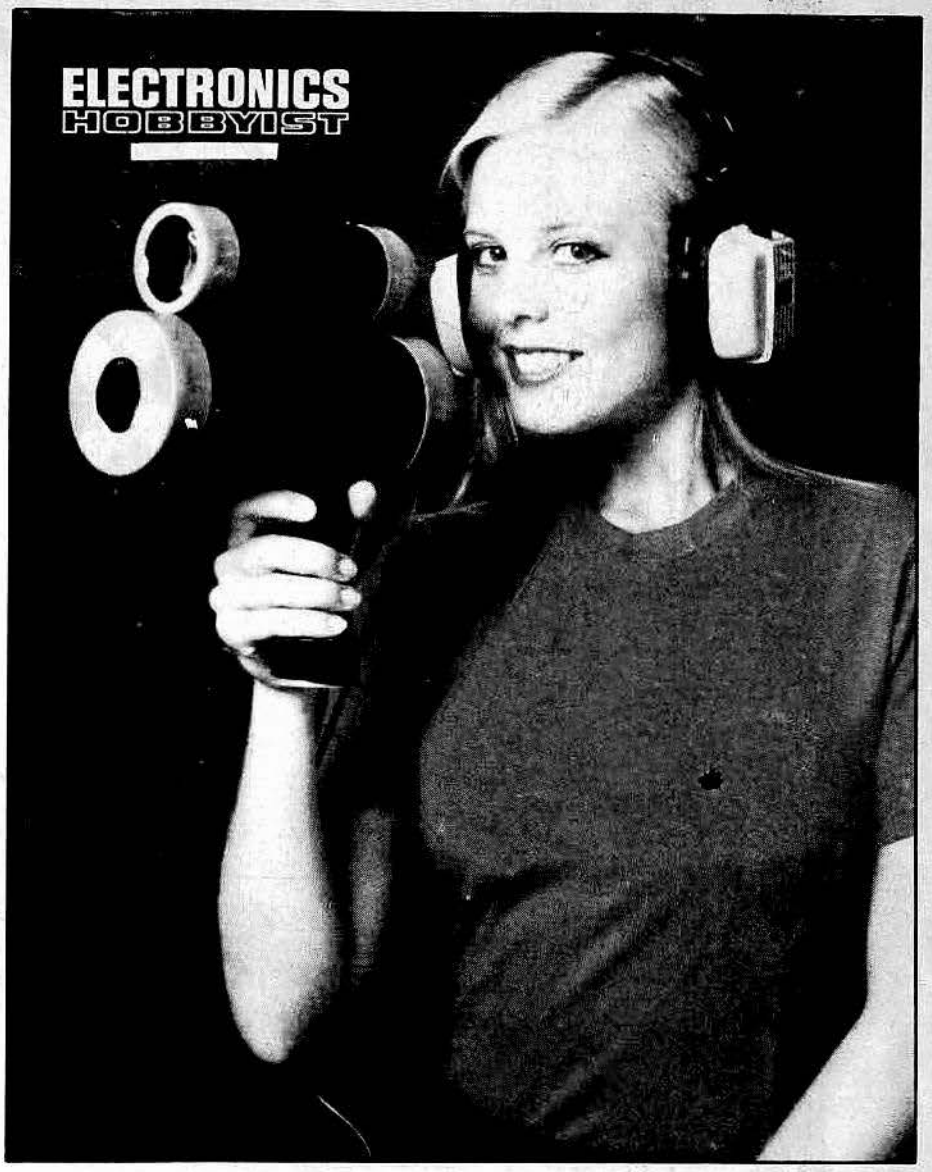


Light Beam Communicator

Talk over a beam of light with this transceiver

HAVE YOU EVER TRIED to communicate when skip was coming in over the CB band? Interference from local stations, was only exceeded by interference from long distance stations. The channels were so crowded that stations were as tight as packed sardines. Communication was impossible. There is an intriguing solution to this common problem. Leave the roaring CB crowd behind, and escape up to the light waves.

The Light Beam Communicator described here demonstrates how a light beam can be used for voice transmission. This communicator is also useful to trap intruders at a remote location, and as a top secret communications link between two stations.

The clarity and quality of audio reproduction is crystal clear, with more than enough pick-up sensitivity and modulation power than normally would be needed. Range of the units should be line of sight up to 1000 meters or better. Alignment is easily accomplished by sighting along the barrels of the units. Short range communication (several hundred meters) is easily accomplished by simple sighting to one another's respective units. Long range setups are more conveniently obtained using a camera tripod. Units are built in a pistol-type configuration with all power and optics self-contained. A rear panel contains the necessary controls for operating along with jacks for headsets and a built-in microphone. The device is designed so that it also can be used for actual "listening" to other light sources such as TV pictures, scopes, fluorescents and many other infra-red and invisible radiation sources.

Normally, the units are built using a visible red transmitter for ease and convenience in nighttime alignment. For serious longer range, low noise performance they can be equipped with optional filters for invisible infra-red transmitting capabilities.

Looking at The Circuit. The light beam transmitter-receiver consists of a phototransistor receiver which picks up modulated light that is fed through a high gain amplifier and then to headsets or a loud speaker. When in the transmit mode, the amplifier becomes a sensitive mike pre-amp that drives a current amplifier modulating a light emitting diode as the transmitter.

The receiver section consists of a phototransistor (Q4) positioned at the focal point of lens LE2 inside enclosure EN2 (A separate enclosure, lens and phototransistor for transmitting and receiving enhances the flexibility and performance of the device. This, however, adds to the cost. Duplicating these components for both functions could be done, however, overall performance is sacrificed.)

Q4 is mechanically secured to a sliding dowel DO1 that is adjusted to its proper distance from LE2 and secured with a screw. The signal from Q4 is fed into J1 via a shielded cable to keep hum and other electrical pick-up to a minimum. Switch S2A now selects J1 in the *receive* mode and feeds the signal to the amplifier via C1. The signal is now matched and amplified via the integrated circuit U1. A gain control R7 controls the sensitivity of the amplifier and also serves as an ON/OFF switch for the receiver section. The output of U1 is now further amplified by Q1 and impedance matched via transformer T1. S2B now connects T1 and J2 for feeding 8-ohm headsets or an external speaker.

The transmitter section consists of a narrow beam visible red or optional infra-red light emitting diode LED1 located at the focal point of lens LE2 inside enclosure EN1. EN1 also contains the electronics and controls for hand grip EN3. A mike M1 is lo-

Light Beam Communicator

cated on the rear panel RP1 and is fed to the amplifier U1 through C1 via mode select switch S2A. The amplifier now becomes a pre-amp for the mike. The output of the preamp is further amplified by Q1 and impedance matched by T1. The output of T1 is fed to Q2 via S2B. Q2 is DC coupled to Q3 whose quiescent state is selected via R15 in determining the DC current through LED1. A modulation signal is AC coupled to Q2 via C8. The hole is covered to minimize random light or noise in the circuit.

Power for the transmitter section Q2, Q3 and LED1 is from battery B3, is controlled by S2C and is used only during transmit mode. This enables the device to be used as a receiver. used as a receiver.

Construction. Begin by making the following parts. The parts list supplies details on how to purchase the items already fabricated. The main enclosure EN1 is an 8-inch long piece of PVC tubing, with a 3½-inch outside diameter. This is sometimes called schedule 40 PVC tubing. PVC tubing is obtained in plumbing supply stores, hardware stores or building supply outlets.

Cut a 2-inch hole for the handle, using a hole saw. As the assembly diagram shows, this hole is located 3 spectively from the rear end. File a ¼-inch slot on each side of the hole that is 2½-inches from the back of EN2. Remember to curve the slot to take into account the pivoting action of EN2's other screw when optical alignment is later attempted.

piece of PVC tubing with a 2⅜-inch outside diameter. Next, drill a ¾-inch hole approximately 3 inches from the rear end of the receiver enclosure. This hole is for optical alignment. There are two mating holes to secure the receiver enclosure to EN1. These holes are on top of the piece to allow access with a screwdriver. The bore axis of these two tubes must be parallel. The large ¾-inch hole can be covered with a plug or a piece of tape.

Transformer T1 has a 3:1 turn ratio of 1500 to 500 turns.

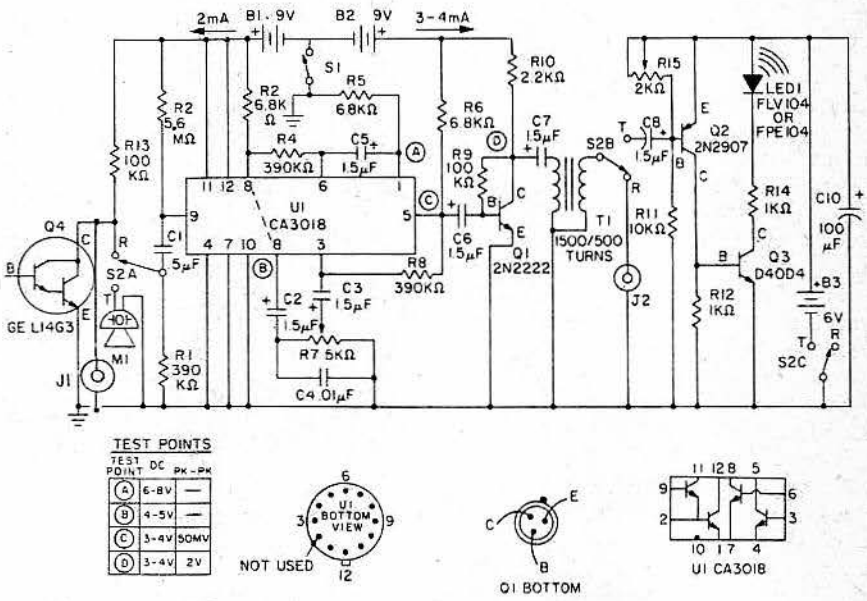
The handle and battery enclosure EN3 is a 6-inch long piece of PVC tubing (schedule 40) with a 2-inch outside diameter. Insert the handle after everything has been assembled, and glue it with PVC cement.

PARTS LIST FOR LIGHT BEAM COMMUNICATOR

C1—0.5-mF, 25-VDC disc capacitor
C2, 3—1.5mF, 35-VDC tantalum capacitors
C4—.01-mF, 25-VDC disc capacitor
C5-8—1.5mF, 35-VDC tantalum capacitors
C9—.01-mF, 25-VDC disc capacitor, across battery, omitted in this model.
C10—100-mF, 25-VDC electrolytic capacitor
J1, 2—RCA jacks
LED1—Small light emitting diode, visible red, FLV104 or infra-red, FPE104
M1—small crystal mike (any type)
Q1—2N2222 NPN transistor
Q2—2N2907 PNP transistor
Q3—D40D4 NPN transistor
Q4—GE L14G3 phototransistor
R1—390,000-ohm ¼-watt, 10% resistor (all resistors 10% unless otherwise noted)
R2—5,600,000-ohm, ¼-watt resistor
R3—6,800-ohm, ¼-watt resistor
R4—390,000-ohm, ¼ watt resistor
R5, 6—6,800-ohm, ¼ watt resistors
R7—5,000-ohm potentiometer with SPST switch (see S1 below)
R8—390,000-ohm, ¼-watt resistor
R9—100,000-ohm ¼-watt resistor
R10—2,200-ohm, ¼-watt resistor
R11—10,000-ohm, ¼-watt resistor
R12—1,000-ohm, ¼ watt resistor
R13—100,000-ohm, ¼ watt resistor
R14—27-ohm, ½-watt resistor
R15—2,000-ohm trimmer potentiometer
S1—SPST switch, part of potentiometer R7 above.
S2—Switch, 3-pole, 2-position rotary
T1—Transformer, 1500 turns primary winding 500 turns secondary winding
U1—CA3018, high gain amplifier

Misc.

BH1—4 AA battery holder snaps
CA1, 2—3½-inch plastic cap
CA3, 4—2⅜-inch plastic cap
CA5—1⅝-inch plastic cap
EN1—8-inch, 3½-inch OD PVC
EN2—6½-inch, 2⅜-inch OD PVC
EN3—6-inch, 2-inch OD PVC



BU1—nylon ⅜-inch bushing
CL1, 2, 3—10-inch battery clips, 9-V
WR1—10-inch shielded cable
P1—RCA plug
TA1—3-inch double sided tape, ½-inch
DO1—2-inch wood dowel, 1½-inch diameter
RP1—Rear panel, 3¼ x 3¼ inch, 22 gauge
MP1—Mounting plate, 2⅞ x 5½ inch, 22 gauge
SW1—2-each, 6-32 x ¼-inch screws & nuts
SW2—2-each, 6-32 x 1-inch screws & nuts
LE1, 2—Lenses, 54 x 89mm
PC1—Printed circuit board
KN1, 2—small plastic knobs
HS1—8-ohm headsets with matching transformer (not included in kits)
B1, 2—9-volt transistor batteries
B3—Four 1½ volt AA batteries

FTR1—Filter for infra-red light emitting diode
WR2—24-inch piece of #24 blue stranded hook up wire
WR3—24-inch piece of #24 red stranded hook up wire
WR4—6-inch of No. 24 buss wire

The Light Beam Communicator is available in three different kit formats. They are:
Electronic kit for one set (two units) . . $59.50
All the mechanical and optical parts for 1 set (2 units) $39.50
Combination of electronic, mechanical, and optical parts to fully assemble 1 set (2 units) $99.00

Send stamped, self-addressed envelope to Information Unlimited, P.O. Box 716, Amherst, NJ 03031 for parts availability.

The rear plate RP1 can be fabricated from a 3¼ x 3¼-inch square piece of No. 22 galvanized sheet metal or .035 aluminum. Use the RP1 template shown to locate the holes. The mounting plate MP1 is made from a 2⅞ x 5½-inch square piece of galvanized sheet metal (No. 22) or .035 aluminum. This time, use the MP1 template to locate the holes in this piece.

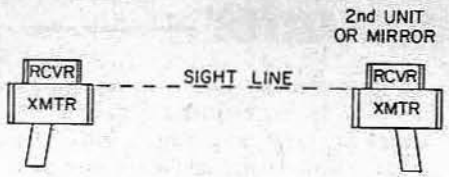
Centering dowel DO1, has a 2-inch length and an outside diameter of 1½-inches. It should fit smoothly in to EN2. The cable, WR1, is fed to the phototransistor, Q4, through a slightly off center feed hole in the dowel. The connection is made by soldering to the exposed leads of Q4. The leads should be as short as possible, and glued with RTV cement. The leads should be only long enough to allow touch up, re-positioning to the true optical axis.

The plastic cap CA1 is 3½ inches, with a 1⅝-inch hole in the center. Use a sharp knife or small snips. If you are not neat in this procedure, the appearance of the device can be ruined. Four small pieces of double sided tape (TA1) are used for securing the lens LE1 to the cap. Be sure that the tape does not contact the ridge of EN1, otherwise it will be difficult to remove for checking. The other plastic cap CA2 is 3½-inch. It has a ¼-inch lip to hold the sub-assembly into EN1.

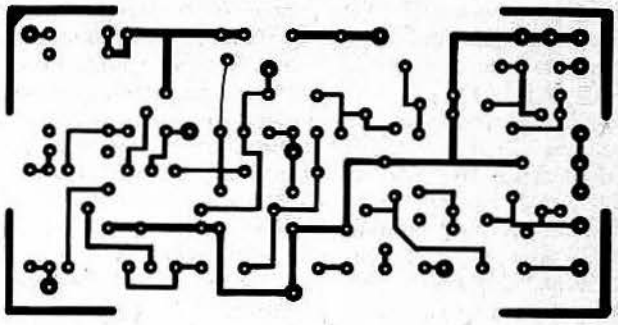
CA3 is the 2⅜-inch plastic cap. Remove the ⅜-inch lip, to retain lens, LE2, and optional filter FTR1. These are fitted against the end of EN2. CA4 is a 2⅜-inch plastic cap. Place a small hole for cable WR1, to create a friction hold and prevent DO1 from sliding once set. After alignment, secure with RTV cement. These plastic caps are available from Information Unlimited (refer to parts list).

It would be preferable to construct all circuits on a board, unless you are very familiar with perf-board assembly. If so, a 3 x 1½-inch perf-board, with a .01-inch grid, may be used. Follow the layout as shown in the printed circuit board layout. As always, use resin-core solder when you build this project. Remember to remove any excess solder from the PC board to prevent shorting.

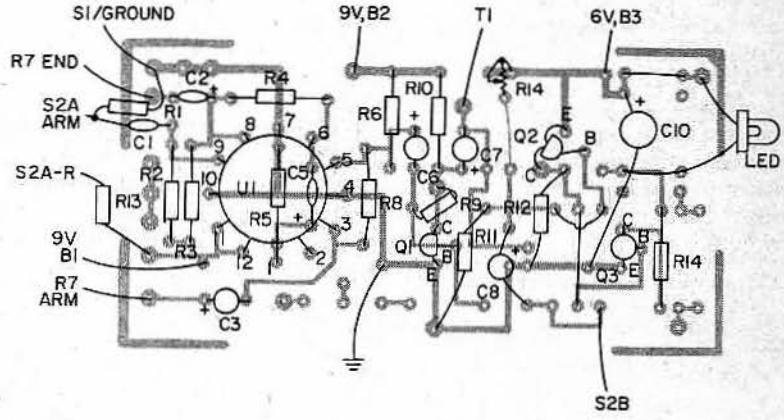
Assemble RP1 as shown in Figure three. Attach R7 to RP1 as illustrated in Figure two; the leads from R7 must be twisted and as short as possible. Connect C4 to S2 and then attach the assembly to RP1. Twist all wires together leading to S2. Route these leads close to metal. Switch leads are all identified in the schematic. Attach microphone M1 using RTC cement. Position and wire as shown. Assemble jacks J1 and J2.



Positioning Light Beam Communicator for two-way communication is line-of-sight. With ideal conditions, it is possible to send and receive up to a mile.



If you are not an expert at etching your own circuit boards, we suggest you buy the kit from Information Unlimited, which includes PC board and parts.



The parts overlay shows components on top of PC board. Note that all of the electronic components fit handily on board, making for easy assembly.

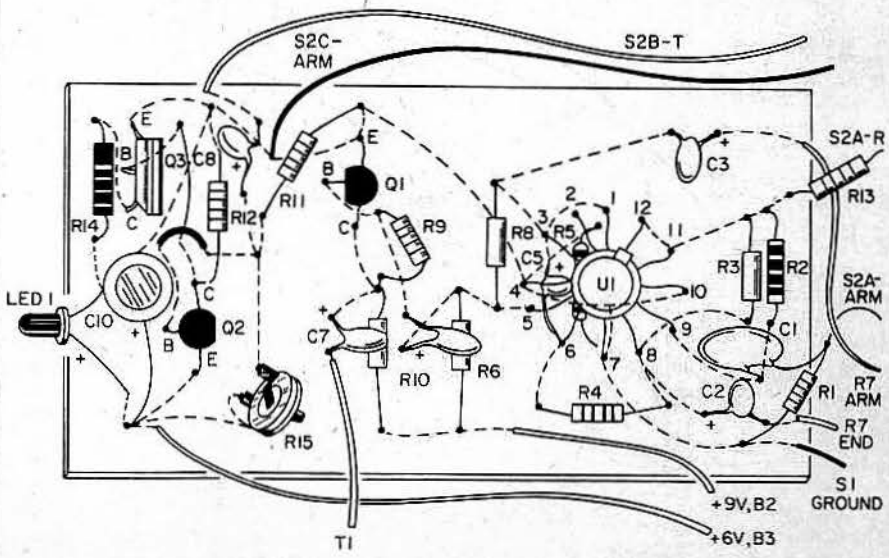


Fig. 1. Actual parts placement on the Light Beam Communicator's board is not critical; however, you must identify all of the leads going to the components to avoid confusion.

Attach RP1 to MP1 via screws SW1 (6-32 x ¼-inch)

Construct PC1 according to the circuit foil pattern given on the preceeding page. Assemble the board by using the schematic diagram given and Figures one and two. Note polarity of tantalum and electrolytic capacitors and the position of U1, Q1, Q2, Q3 and LED1.

Connect the wires from RP1 assembly to board noting identification of leads shown in sketches. Position as shown in Fig. 2, but do not adhere to tape at this time. Carefully position LED1 into B3 as shown. Attach battery clips CL1, 2 and 3 to respective points, as shown in Fig. four. It is advantageous at first to allow the board freedom to be moved for total access during preliminary trouble shooting and testing. Leads may be further shortened after several minutes of proper operation have been verified.

Next, attach T1 to MP1, bending tabs in the small holes. Solder one lead from primary to secondary and sandwich between core of T1 and plate. This makes the ground contact of the transformer. You may want to solder these wires directly to the plate for a positive contact. Use a heavy iron for this. Note ungrounded 500-ohm lead going to S2B and ungrounded 1.5K ohm (winding marked P) going to C7 on board.

Connect PL1 phone plug to WR1 cable from receiver section.

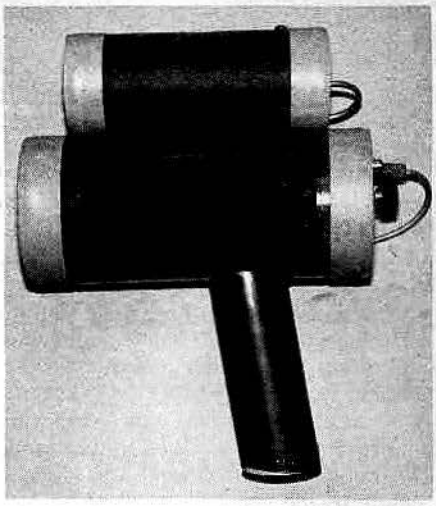
Testing The Units. It is assumed that the assembled unit, to this point, has been wired correctly, with no shorts, and good solder connections. You will note that the complete working unit is conveniently built on a single removable assembly. This assembly should have the battery clips CL1, 2 and 3 connected to their respective batteries.

Testing The Receiver. Turn S2 and R7 fully counterclockwise.

Connect one terminal of a fresh 9-volt battery to CL1 and connect a 100-mA ammeter between the contact of the battery and the clip. Turn on R7. Current reading should be approxmately 2-mA. Fully connect battery and designate B1.

Repeat above using a second battery connected to CL2. Turn on R7/S1. Current reading should be 3 to 4-mA. Fully connect battery designated B2.

Plug a high impedance set of headphones into J2. HS1 is a standard



Side view of the Light Beam Communicator

8-ohm headset with a spliced in matching transformer that steps up to 1000 ohms. This is suggested, as high impedance headsets are scarce and uncomfortable to wear). Plug PL1 from Q4 (receiving phototransistor) into J1.

Turn on R7/S1 and slowly turn up gain until a loud 60-cycle hum is heard. This is the normal AC room lighting frequency being picked up by Q4. At normal ambient lighting conditions it will completely block the amplifier. Reduce the gain and attempt to point Q4 at various objects indicating different levels of signal, depending on reflection characteristics of surfaces, etc. You will note that the circuit is relatively prone to power line hum pick up. It is assumed that testing will be done in normay electrical lighting for this step. If not, you may not obtain the 60Hz hum.

If everything above checks out OK, you can proceed to the transmitter section. If not, troubleshoot the faulty circuit. It may be convenient to use the test points shown on the schematics and thoroughly familiarize yourself with the circuit description given in the beginning of the plans.

Testing The Transmitter. With all switches full counterclockwise, connect CL3 to 6-volt B3 as done with B1 and B2. Connect a 100-mA meter in series and turn S2 clockwise to the transmit position. Adjust R15 to read 25-50-mA. LED1 should light to about one-half maximum brilliance. Turn R7/S1 and note LED1 changing brilliance with sounds. Whistle. The current meter should jump to nearly 100mA. *Note:* LED1 increases in brilliance with sound indicating upward modulation. The device seems to work all right with the

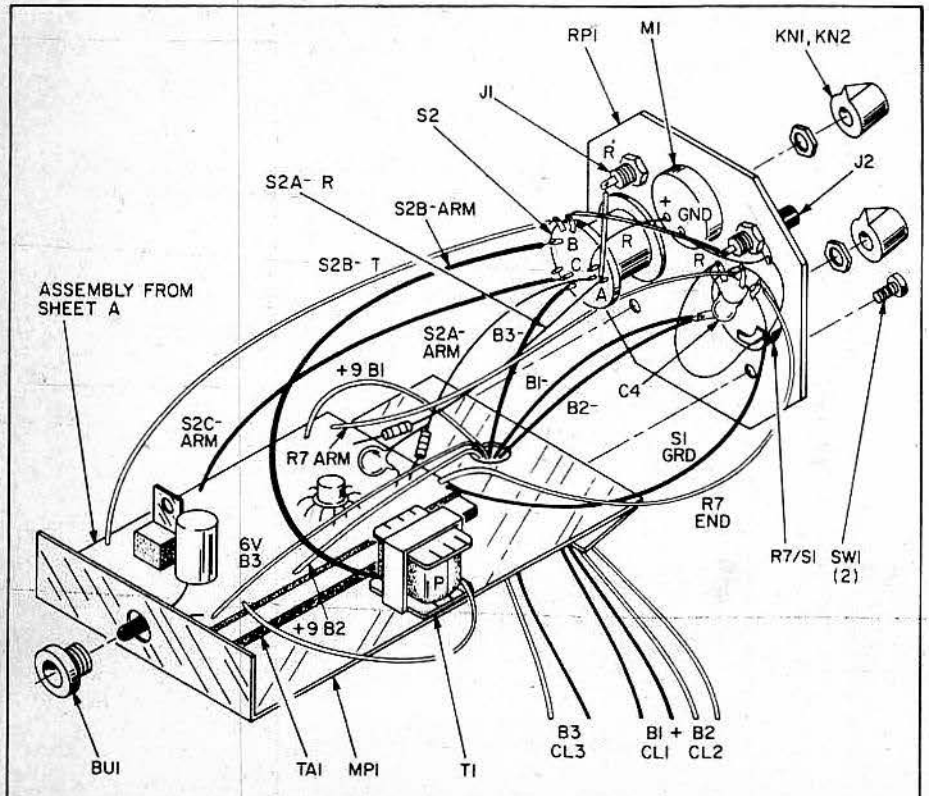
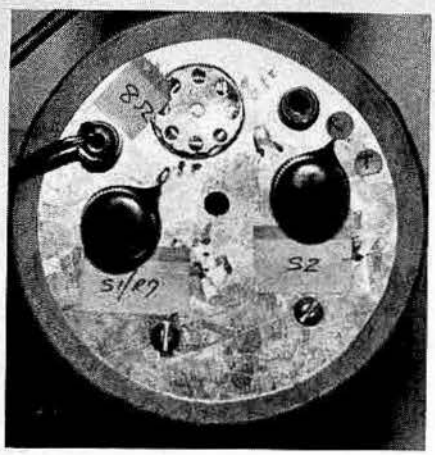
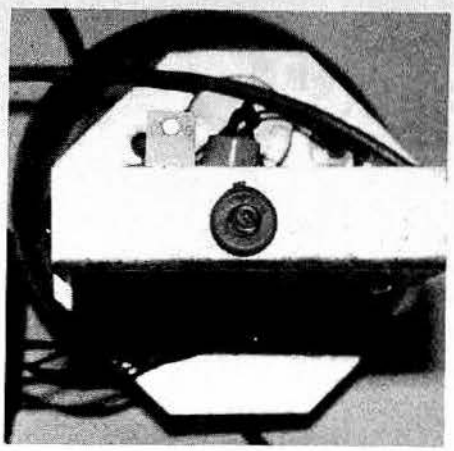


Fig. 2. Leads from the board to the rear plate assembly (RP1) are positioned as shown here. Leave plenty of free play in the leads to allow for adjustments to the device.



This photo of the back end of the transceiver shows mike, mode, volume controls.



The LED, either in normal or infra-red configuration, is the heart of the transmitter.

LED1 downward modulating, but we recommend upward modulating. Certain diodes may require less current than 50-mA for good upward modulation.

You are now ready for final assembly of the unit, and optical alignment. Note that LED1 should automatically center itself inside of EN1.

Optical Alignment. In order to obtain maximum performance from your light beam communicator, it is necessary to properly optically align both transmiter and receiver according to the sight line diagram.

You will note that the receiver tube EN2 is secured to EN1 via screws. The rear hole is slotted to allow a side to side movement of the receiver enclosure in respect to the transmitter enclosure. The up and down position usually self-adjusts simply by the abutting of the two enclosures. Remember that both receiver and transmitter sections must be optically aligned to view the same area for maximum two-way communications.

The method we demonstrate here is not necessarily the only way to align these devices and is only suggested as a possible means. The builder may have his own ideas and methods for accomplishing the above.

The following steps were used at our lab and found to be relatively easy in accomplishing acceptable alignment.

1. Remove transmitter lens and cover and place some thin paper over open end. Adjust LED1's output to the center of paper (this is the bore sight of enclosure). Secure and replace the lens and cover.

2. Secure communicator in vise or other similar holding attachment.

3. Locate a mirror about 20 feet from the device.

4. With transmitter properly aligned and secured, adjust mirror for reflection of output light occuring in receiver lens. This is adjusted by sighting mirror reflection along sight line at surface intersection of the two enclosures (note drawing).

(Continued on page 96)

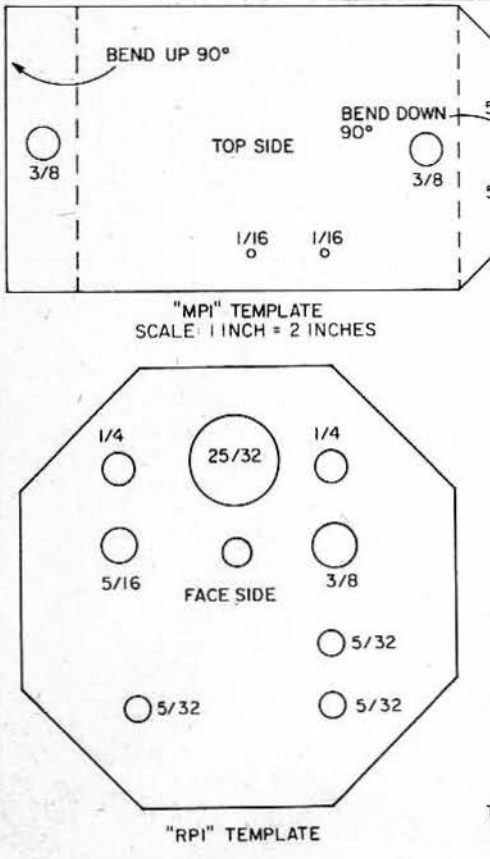


Fig. 3. This diagram shows the dimensions of the board and back plate mountings for Light Beam Communicator unit assembly.

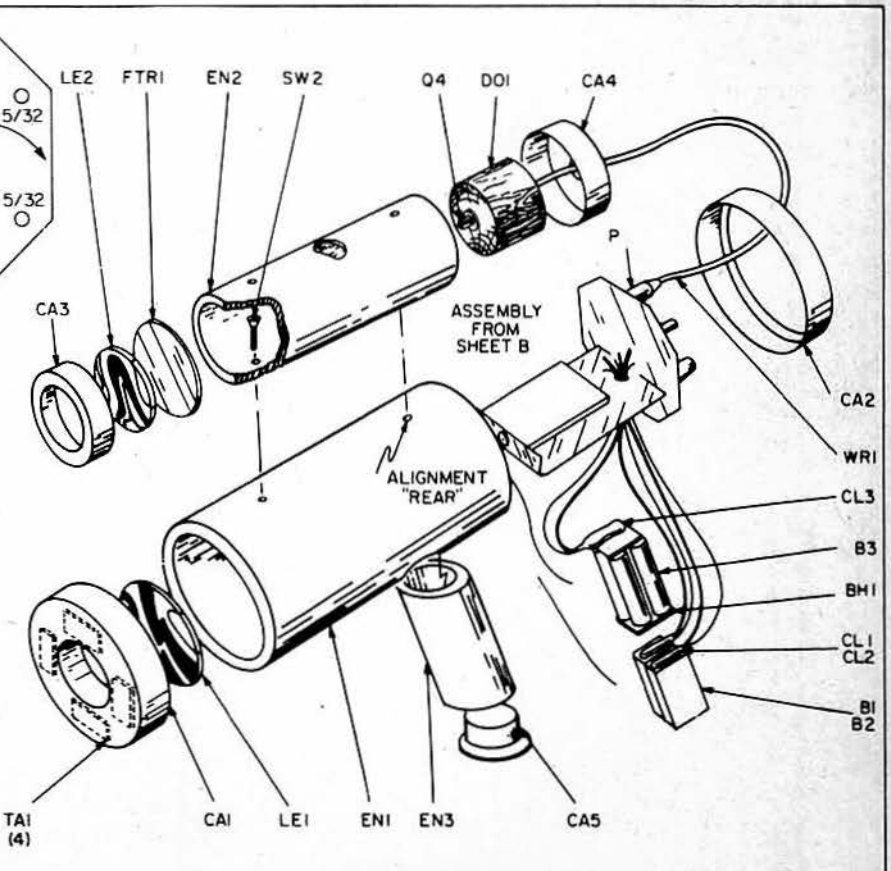


Fig. 4. This exploded view diagram shows the placement of the boards, housing, lenses and other parts necessary for construction and operation of Light Beam Communicator.

Light Beam

(Continued from page 39)

5. With the device and mirror aligned as above, carefully adjust the position of the receiver enclosure so that the focused received beam is centralized (bore sighted) inside the tube. This is best accomplished by placing a thin strip of paper through the adjust hole over the phototransistor and adjusting the dowel to the focal length of the lens. This should place the focused received light directly on the lens of the phototransistor. Further touch up can be done by careful positioning of the phototransistor with needle nose pliers. Secure dowel, enclosures, etc., to eliminate movement and improper alignment.

6. Repeat with the other unit. You should now be able to hand-sight units along sight lines for medium range use. Good, reliable long range use should be done with a camera tripod. Nighttime use, with the visible red transmitting diodes is easily accomplished at ranges up to 1,000 meters or so by noting the reflection of the transmitting light in the receiving lens as noted at the transmitter station. Day-time operation is best with filter and IR transmitter. Securing of optical components via permanent means should only be done when optimum optical alignment can be assured.

Operation. For both transmitter and receiver to be in the OFF mode. S2 must be at R position and R7 to the OFF mode.

To use receiver only, plug in headsets to J2 jack and turn on R7 and adjust to desired level (usually no more than ⅛ turn). Point unit at a normal 60Hz lamp, TV or other light source and note hum.

To use in transmit mode, all that is necessary is to place S2 from the R to the T mode. The modulation level is preset by R7 when used in the receiver mode.

One way to test is to look into the transmitter section and note the LED flickering with audio signals. R7 can then be readjusted if necessary by this indication. Note that the LED only has to change ever so slightly for sufficient modulation.

You will see there is a trimpot R15 on PC board. This adjusts the quiescent current through this LED and should be set just where the LED is emitting with no audio signal. This saves batteries and prevents downward modulation. This probably should be reset as batteries weaken. Also, note that the units pick up 60Hz hum from power lines and normal lighting. The visible red LED (supplied in these units) obviously operates best in darkness. For normal daylight operating, the infra-red LED and filter must be used.

In general, reception is possible as long as the transmitter output light can he seen by the naked eye.

Applications. Aside from the line of sight communications possibilities, this communicator is extremely useful for surveillance applications. Install one of the communicators in a location that is vulnerable to trespass by intruders. You can buy an inexpensive sound activated alarm, with its microphone taped to an earphone. The alarm will be activated whenever there is noise.

Another appliation is Morse code practice. Two people up to a mile apart, with a pair of practice code oscillators, can use the Light Beam Communicator to sharpen their code skills. ■

Oil Pressure

(Continued from page 57)

have a machine shop thread an extender pipe to that car's metric specs. Stop the oil leaks before they occur by using a pipe cement or plumber's teflon tape when assembling the fittings. Exercise caution when tightening this fragile piping, especially when tightening it in the motor block. It is frustrating work to remove a sheared piece from the motor block hole.

Conclusion. There you have it, a relatively easy (as promised) method of keeping watch on one of your car's most important systems. Combined with the digital voltmeter and temperature gauge, and those gauges coming up in later issues, this represents one of the most important weapons you can have in your arsenal in the fight against the ever-rising costs of automotive maintenance and repair. In addition, you will possess a set of instruments of fargre¼ter accur¼cy than those analog devices commonly available for aftermarket installation. This is one instance in which you could not possibly buy anything better than what you can put together on your workbench in a few hour's time. ■

Sloping Dipoles

(Continued from page 78)

with the clips disconnected. Since it was easy to raise the antenna up and down with the halyard, there was no great problem in changing over the antenna between 10 and 20-meter operations.

Conclusion. In summary, the sloper antenna advantages are very low cost and good performance. It is easy to erect, and requires only a single high-point support. The other end of the antenna is near ground-level, making it easy for trimming and tuning to some specific frequency or band. It performs well as a receiving antenna.

There is some directivity even though it does well as an omni-directional antenna system. Good DN performance may largely be the result of low angles of radiation, but for whatever reason, it does the job. ■

Binary/BCD Tester

(Continued from page 64)

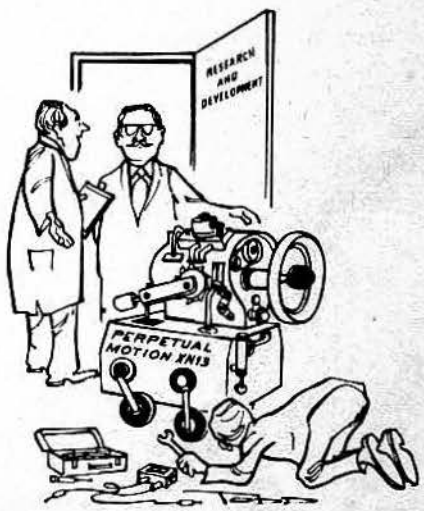
three 74LS47's which convert the BCD to seven segment LED display format. The outputs of the 74LS47's are connected to common anode seven segment LED displays through resistors. The values of the resistors depend on the size of the LED displays, the brightness of the displays that you desire, and the amount of current that you are willing to expend on the displays. Normally the resistors should be between 330 ohms and 470 ohms.

The 74LS47's are programmed to provide leading zero suppression.

Construction. The IC's and resistors can be mounted on any type of board you prefer (PC, wirewraping, etc.).

Connect a long wire (about one foot) to the common V+ on the board, and an equally long wire to the common ground. Solder a red insulated clip (such as Radio Shack catolog number 270-1545) to the other end of the wire to V+, and a black alligator clip to the other end of the wire to ground. These will be your power supply lines for the converter. Connect a 10μf across these two wires.

Connect a one foot long wire to each of the input pins on the two 74LS47's. These are pins 2,3,6 and 7. Solder an insulated clip (any color) to the other end of each of these wires. Label each of these wires near the clip with the notation from 2^0 through 2^7. Figure 1 shows which label goes on the wire to each 74LS75 pin (2^0 for pin 2 of 74LS75 #1, 2^1 for pin 3 of 74LS75 #1, and so on). ■



"We're right on the threshold, sir . . . but we've hit one snag . . . it keeps stopping!"